new claims 23 - 50 is appropriate. The replacement claims have been amended from the PCT as shown in Exhibit B attached. No new matter is added to this case by these changes to the claims.

Respectfully submitted,

FLEIT, KAIN, GIBBONS, GUTMAN & BONGINI, P.L.

CERTIFICATE UNDER 37 CFR 1.8(a)
I HEREBY CERTIFY THAT THIS CORRESPONDENCE IS BEING DEPOSITED WITH THE U.S. POSTAL SERVICE AS FIRST CLASS MAIL IN AN ENVELOPE ADDRESSED TO ASSISTANT COMMISSIONER FOR PATENTS WASHINGTON, D.C. 20231 BOX ____ ON 12-20-01

Reg. No. 30648
Date 12-20-01

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EXHIBIT A

Claims

1. A transducer element of a magnetic material for a torque or force sensor which comprises at least one annulus of magnetised material extending about an axis,

the at least one annulus being magnetised such that a closed loop of magnetic flux is established in the magnetic material,

the at least one annulus being responsive to a torque applied about said axis for a torque sensor or to a bending moment acting about said axis due to an applied force for a force sensor, as the case may be, to emanate a magnetic field component externally of said element that is a function of the applied torque or the applied force, as the case may be, characterised in that:

the magnetisation established in the at least one annulus provides a torque-dependent magnetic field component which has a significant non-zero value at zero torque or force and an essentially zero value at a non-zero torque or force, as the case may be.

2. A transducer element as claimed in Claim 1 in which the at least one annulus is in the form of an annular ring attachable to a shaft, and the annular ring is of a magnetoelastic material and is circumferentially magnetised.

3. A transducer element as claimed in Claim 1 in which the at least one annulus is of magnetoelastic material and is a circumferentially magnetised, integral portion of a shaft.

4. A transducer element as claimed in Claim 1 in which the at least one annulus is longitudinally magnetised in the direction of said axis.

5. A transducer element as claimed in Claim 4 in which the at least one annulus is an integral portion of a shaft.

6. A transducer element as claimed in Claim 2 or 3 comprising a first annulus of magnetised material and a second annulus of magnetised material, wherein said first annulus provides an essentially zero value of magnetic field component at a non-zero torque or force of a given polarity and said second annulus provides an essentially-zero value of magnetic field component at a non-zero torque or force of the opposite polarity.

7. A transducer element as claimed in claim 4 or 5 comprising a first annulus of magnetised material and a second annulus of magnetised material, wherein said first annulus provides an essentially zero value of magnetic field component at a non-zero torque or force of a given polarity and said second annulus provides an essentially-zero value of magnetic field component at a non-zero torque or force of the opposite polarity.

8 A transducer element as claimed in Claim 1 in which said element has a surface extending radially of said axis and comprising a first annulus of magnetisation extending to said surface and a second annulus of magnetisation extending to said surface outwardly of said first annulus, said first annulus and said second annulus

being magnetised to provide a magnetic field component therebetween which has a significant non-zero value at zero torque or force, as the case may be, and an essentially zero value at a non-zero torque or force, as the case may be.

9. A transducer element as claimed in Claim 8 in which said first annulus is magnetised in the direction of said axis with a pole of given polarity at said surface and in which said second annulus is magnetised in the direction of said axis with a pole of opposite polarity at said surface.

10. A transducer element as claimed in Claim 8 in which said first annulus and said second annulus are each magnetised to form a respective closed loop of circumferential magnetisation, and the respective closed loops of circumferential magnetisation are of opposite polarity.

11. A transducer element as claimed in Claim 5 or Claims 7 and 5 comprising a respective further annulus of magnetisation located radially inwardly of the at least one annulus of magnetisation and longitudinally magnetised in the axial direction with a polarity opposite thereto to form a closed loop of magnetic flux therewith.

12. A transducer assembly comprising a transducer element as claimed in Claim 1 and a magnetic sensor arrangement oriented to detect said magnetic field component.

13. A transducer assembly comprising a transducer element as claimed in Claim 2 or 3 and a respective magnetic sensor arrangement for the at least one magnetised annulus and oriented to detect a magnetic field component in the direction of said axis.

14. A transducer assembly comprising a transducer element as claimed in Claim 4 or 5 and a respective magnetic sensor arrangement for the at least one magnetised annulus and oriented to detect a magnetic field component in the circumferential (tangential) direction about said axis.

15. A transducer assembly comprising a transducer element as claimed in Claim 6 and first and second magnetic sensor arrangements for detecting a respective magnetic field component emanated by said first annulus and said second annulus, each of said first and second magnetic sensor arrangements being oriented to detect a magnetic field component in the direction of said axis.

16. A transducer assembly comprising a transducer element as claimed in Claim 7 and first and second magnetic sensor arrangements for detecting a respective magnetic field component emanated by said first annulus and said second annulus, each of said first and second magnetic sensor arrangements being oriented to detect a magnetic field component in the circumferential (tangential) direction about said axis.

17. A transducer assembly comprising a transducer element as claimed in Claim 8 and a magnetic sensor

arrangement oriented to detect said magnetic field component provided between said first annulus and said second annulus.

18. A transducer assembly comprising a transducer element as claimed in Claim 9 and a magnetic sensor arrangement located to be responsive to the magnetic field between said first annulus and second annulus and oriented to detect a magnetic field component in the circumferential (tangential) direction about said axis.

19. A transducer assembly comprising a transducer element as claimed in Claim 10 and a magnetic sensor arrangement oriented to detect a radially directed magnetic field component between said first annulus and said second annulus.

20. A torque sensor system comprising a transducer assembly as claimed in Claim 15 or 16 responsive to torque applied about said axis, wherein said first and second magnetic field sensor arrangements provide first and second torque-dependent signals respectively, and further including signal processing means which comprises a first channel responsive to at least one of the first and second torque-dependent signals, said first channel comprising an output means having a controllable gain for producing an output signal representing a measure of torque, and which also comprises a second channel comprising means for combining the first and second torque-dependent signals to provide a reference signal, said output means being responsive to said reference

signal to adjust its gain in a sense acting to eliminate changes in the response relating the first and second torque-dependent signals with torque.

21. A torque sensor system as claimed in Claim 20 in which the combining means is operable to effect a difference operation on said first and second torque-dependent signals.

22. A torque sensor system as claimed in Claim 21 in which the first channel is responsive to both of said first and second torque-dependent signals to effect a summing operation thereon.

23. A method of forming a transducer element which is as claimed in any one of Claims 1 to 5 in which the magnetisation of said at least one annulus is performed while the transducer element is under a predetermined torque about said axis.

24. A method of forming a transducer element which is as claimed in Claim 6 or 7 in which the magnetisation of the first annulus is performed while the transducer element is under a predetermined torque of one polarity about said axis, and the magnetisation of the second annulus is performed while the transducer element is under a predetermined torque of the opposite polarity about said axis.

25. A method of forming a transducer element as claimed in Claim 6 or 7 in which the respective magnetisations of the first annulus and the second annulus are performed to provide magnetisations of opposite polarity.

26. A method as claimed in Claim 24 in which the magnetisations of the first annulus and the second annulus are of the same polarity.

27. A method as claimed in Claim 25 in which the magnetisation of the first annulus is performed under a predetermined torque of opposite polarity to that applied in the magnetisation of the second annulus.

28. A method of forming a transducer element which is as claimed in Claim 8, 9 or 10 in which the magnetisation of said first annulus and said second annulus is performed while said element is under a predetermined torque about said axis.

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EXHIBIT B

Claims

23 1. A transducer element of a magnetic material for a torque or force sensor which comprises: at least one annulus of magnetised material extending about an axis,

the at least one annulus being magnetised such that a closed loop of magnetic flux is established in the magnetic material,

the at least one annulus being responsive to a torque applied about said axis for a torque sensor or to a bending moment acting about said axis due to an applied force for a force sensor, as the case may be, to emanate a magnetic field component externally of said element that is a function of the applied torque or the applied force, as the case may be, ~~characterised in that:~~

the magnetisation established in the at least one annulus provides a torque-dependent magnetic field component which has a significant non-zero value at zero torque or force and an essentially zero value at a non-zero torque or force, as the case may be.

24 2. A transducer element as claimed in Claim 23 in which the at least one annulus is in the form of an annular ring attachable to a shaft, and the annular ring is of a magnetoelastic material and is circumferentially magnetised.

25 3. A transducer element as claimed in Claim 23 in which the at least one annulus is of magnetoelastic material and is a circumferentially magnetised, integral portion of a shaft.

26 4. A transducer element as claimed in Claim ~~1~~ 23 in which the at least one annulus is longitudinally magnetised in the direction of said axis.

27 5. A transducer element as claimed in Claim ~~4~~ 26 in which the at least one annulus is an integral portion of a shaft.

28 6. A transducer element as claimed in Claim ~~2 or 3~~ 24 comprising a first annulus of magnetised material and a second annulus of magnetised material, wherein said first annulus provides an essentially zero value of magnetic field component at a non-zero torque or force of a given polarity and said second annulus provides an essentially-zero value of magnetic field component at a non-zero torque or force of the opposite polarity.

29 7. A transducer element as claimed in claim ~~4 or 5~~ 27 comprising a first annulus of magnetised material and a second annulus of magnetised material, wherein said first annulus provides an essentially zero value of magnetic field component at a non-zero torque or force of a given polarity and said second annulus provides an essentially-zero value of magnetic field component at a non-zero torque or force of the opposite polarity.

30 8 A transducer element as claimed in Claim ~~1~~ 23 in which said element has a surface extending radially of said axis and comprising a first annulus of magnetisation extending to said surface and a second annulus of magnetisation extending to said surface outwardly of said first annulus, said first annulus and said second annulus

being magnetised to provide a magnetic field component therebetween which has a significant non-zero value at zero torque or force, as the case may be, and an essentially zero value at a non-zero torque or force, as the case may be.

31 ~~9~~. A transducer element as claimed in Claim ~~8~~ 30 in which said first annulus is magnetised in the direction of said axis with a pole of given polarity at said surface and in which said second annulus is magnetised in the direction of said axis with a pole of opposite polarity at said surface.

32 ~~10~~. A transducer element as claimed in Claim ~~8~~ 30 in which said first annulus and said second annulus are each magnetised to form a respective closed loop of circumferential magnetisation, and the respective closed loops of circumferential magnetisation are of opposite polarity.

33 ~~11~~. A transducer element as claimed in Claim ~~5 or Claims 3 4 and 5~~ 27 comprising a respective further annulus of magnetisation located radially inwardly of the at least one annulus of magnetisation and longitudinally magnetised in the axial direction with a polarity opposite thereto to form a closed loop of magnetic flux therewith.

34 ~~12~~. A transducer assembly comprising a transducer element as claimed in Claim ~~1~~ 23 and a magnetic sensor arrangement oriented to detect said magnetic field component.

35 ~~13.~~ A transducer assembly comprising a transducer element as claimed in Claim 24 ~~2 or 3~~ and a respective magnetic sensor arrangement for the at least one magnetised annulus and oriented to detect a magnetic field component in the direction of said axis.

36 ~~14.~~ A transducer assembly comprising a transducer element as claimed in Claim 26 ~~4 or 5~~ and a respective magnetic sensor arrangement for the at least one magnetised annulus and oriented to detect a magnetic field component in the circumferential (tangential) direction about said axis.

37 ~~15.~~ A transducer assembly comprising a transducer element as claimed in Claim 28 ~~6~~ and first and second magnetic sensor arrangements for detecting a respective magnetic field component emanated by said first annulus and said second annulus, each of said first and second magnetic sensor arrangements being oriented to detect a magnetic field component in the direction of said axis.

38 ~~16.~~ A transducer assembly comprising a transducer element as claimed in Claim 29 ~~7~~, and first and second magnetic sensor arrangements for detecting a respective magnetic field component emanated by said first annulus and said second annulus, each of said first and second magnetic sensor arrangements being oriented to detect a magnetic field component in the circumferential (tangential) direction about said axis.

39 ~~17.~~ A transducer assembly comprising a transducer element as claimed in Claim 30 ~~8~~ and a magnetic sensor

arrangement oriented to detect said magnetic field component provided between said first annulus and said second annulus.

40 ~~18~~. A transducer assembly comprising a transducer element as claimed in Claim ~~9~~ 31 and a magnetic sensor arrangement located to be responsive to the magnetic field between said first annulus and second annulus and oriented to detect a magnetic field component in the circumferential (tangential) direction about said axis.

41 ~~19~~. A transducer assembly comprising a transducer element as claimed in Claim ~~10~~ 32 and a magnetic sensor arrangement oriented to detect a radially directed magnetic field component between said first annulus and said second annulus.

42 ~~20~~. A torque sensor system comprising a transducer assembly as claimed in Claim ~~15 or 16~~ 37 responsive to torque applied about said axis, wherein said first and second magnetic field sensor arrangements provide first and second torque-dependent signals respectively, and further including signal processing means which comprises a first channel responsive to at least one of the first and second torque-dependent signals, said first channel comprising an output means having a controllable gain for producing an output signal representing a measure of torque, and which also comprises a second channel comprising means for combining the first and second torque-dependent signals to provide a reference signal, said output means being responsive to said reference

signal to adjust its gain in a sense acting to eliminate changes in the response relating the first and second torque-dependent signals with torque.

43 ~~21.~~ A torque sensor system as claimed in Claim ~~20~~ 42 in which the combining means is operable to effect a difference operation on said first and second torque-dependent signals.

44 ~~22.~~ A torque sensor system as claimed in Claim ~~21~~ 43 in which the first channel is responsive to both of said first and second torque-dependent signals to effect a summing operation thereon.

45 ~~23.~~ A method of forming a transducer element which is as claimed in any one of Claims ~~1 to 5~~ 23 in which the magnetisation of said at least one annulus is performed while the transducer element is under a predetermined torque about said axis.

46 ~~24.~~ A method of forming a transducer element which is as claimed in Claim ~~6 or 7~~ 28 in which the magnetisation of the first annulus is performed while the transducer element is under a predetermined torque of one polarity about said axis, and the magnetisation of the second annulus is performed while the transducer element is under a predetermined torque of the opposite polarity about said axis.

47 ~~25.~~ A method of forming a transducer element as claimed in Claim ~~6 or 7~~ 28 in which the respective magnetisations of the first annulus and the second annulus are performed to provide magnetisations of opposite polarity.

48 ~~26~~. A method as claimed in Claim ~~24~~ 46 in which the magnetisations of the first annulus and the second annulus are of the same polarity.

49 ~~27~~. A method as claimed in Claim ~~25~~ 47 in which the magnetisation of the first annulus is performed under a predetermined torque of opposite polarity to that applied in the magnetisation of the second annulus.

50 ~~28~~. A method of forming a transducer element which is as claimed in Claim ~~8, 9 or 10~~ 30 in which the magnetisation of said first annulus and said second annulus is performed while said element is under a predetermined torque about said axis.